

Claims

1. A method of automatically focusing a microscope having a light source, an objective lens or lens system, a means to direct incident light through the objective lens or lens system to be reflected by the object, an aperture to limit the spatial extent of the incident light and serve as an illumination pupil, a means to direct at least some of the reflected light to an imaging system, and an imaging system to image the reflected light so directed, the method comprising the steps of directing a beam of light from a light source through an objective of a microscope system to an object whereby light is reflected from the surface thereof; collecting at least some of the light reflected thereby and directing the same to an imaging system, wherein the incident beam of light is limited in spatial extent by imaging an aperture to form an illumination pupil, the centroid of illumination of the illumination pupil is aligned with the incident optical axis of the instrument, and reflected light is projected to the imaging system comprising at least two images from eccentric sections of an imaging pupil differentially displaced from the optical axis, and wherein the separation of the images thereby produced is determined to provide an indication of the object distance.
2. The method of claim 1 wherein an illumination beam is injected into the top focal plane of the objective limited in its spatial extent and bounded by imaging an aperture so as to form an illumination in the top focal plane of the objective.
3. The method of claim 2 comprising the formation of a plurality of images of the object using sections of the imaging pupil with differing eccentricities and projecting the images onto a single imaging means.

4. The method of any preceding claim wherein the imaging means comprises a single detector array.
5. A method of focussing comprising successively repeating the method steps of any preceding claim to obtain separate pairs of images from eccentric sections of the imaging pupil, measurements of the separation of the successive pairs of images being used, for example as part of iterative process, to improve the accuracy of the focusing information and/or to obtain focusing information varying spatially across an object, particularly to accommodate a degree of deviation from planarity.
6. The method of any preceding claim wherein the light that is used for the focus investigation is derived from the same light source as the light which is used for metrology.
7. The method of any preceding claim wherein a beam splitter is used in order to extract light reflected from the sample and direct the same towards a focus optical system and imaging system adapted to investigate the focus condition, the focus optical system being separate from the primary observational optical system which is used to image the object, obtain metrology data or other measured data therefrom, once the focus has been determined.
- 25 8. The method of any one of claims 1 to 6 comprising first investigating the focus condition and subsequently conducting observation and/or measurement of the object via a single optical system with a common imaging means.

9. The method of any preceding claim wherein image separation is achieved by a dihedral mirror arranged so as to simultaneously split the pupil into two and redirect the light from the two portions to different sections of an imaging means.

5

10. The method of any preceding claim wherein a field stop is provided in the illumination beam from the light source.

11. A microscope auto-focus system for the implementation of the method of
10 any preceding claim.

12. A microscope auto-focus system comprising a light source, an objective lens system, a means to direct incident light through the objective lens to be reflected by the object, an aperture to limit the spatial extent of the
15 incident light and serve as an illumination pupil with the centroid of illumination on the optical axis, a means to direct reflected light from the object to an imaging system, and an imaging system, and the system further comprises a means to project reflected light to the imaging system comprising at least two images from eccentric sections of an imaging pupil differentially displaced from the optical axis, and a means to measure the separation of the images thereby produced to provide an
20 indication of the object distance, and means to adjust mechanically the separation of the object being observed from the imaging objective lens, under the control of the focus system.

25

13. A microscope auto-focus system in accordance with claim 12 wherein a first optical and imaging system is provided for focus images to be used to determine optimal focus position in a first focusing step, and a second optical and imaging system is provided for an observational image to be

used in a subsequent observational (for example metrology) step, with a beam splitter and/ or selective optics disposed therebetween to divert reflected light from an object selectively to either imaging system and/ or partially to both.

5

14. A microscope auto-focus system in accordance with claim 12 or 13 wherein the means to project reflected light to the imaging system comprising at least two images from eccentric sections of an imaging pupil includes image separation optics comprising a dihedral mirror.

10

15. A microscope equipped with an autofocus system in accordance with one of claims 11 to 14.